miscellaneous stars and 2,832 American Ephemeris stars were observed; that 'in declination the interpolation of the refractions has been finished,' etc.

A curious impression conveyed by the report is that, excepting the Astronomical Director, who has the most important part of all, the professors seem to have less important work assigned to them than the assistant astronomers have. The perfunctory flavor which permeates the whole report is especially strong in the statements of the work of the telescopes: "The positions of two stars were measured for the use of the twenty-six-inch telescope. Eight occultations of stars by the moon and five eclipses of Jupiter's satellites were observed. The diameter of Venus was measured on seven different days, and the sun was examined for spots on four days." Why on four days and no more? The report of the work of one professor is condensed into a single line with the remark that he assists Lieut. Charles E. Fox, U. S. N.

We must in justice state that the Observatory does other than astronomical work. It prepares and publishes the 'Nautical Almanac;' but this is done at the expense of a separate appropriation which we have not included in our statement of estimated expenditures. There is a department of meteorology and magnetism. Why pursue meteorology in the presence of the Weather Bureau and the Hydrographic Office? Sad havoc has been made with the magnetic observations by the building of an electric railway in the neighborhood. There are also departments of time service and nautical instruments, the value of which to the naval service, it is declared, 'cannot be overestimated.' Is not this statement a little strained? It is true that a very impressive list of scientific instruments issued to ships of the navy is given. But the careful reader who makes inquiry will find that the greater number of them can be purchased at prices ranging from 50 cents to $10 each. Do the inspection, care and issue of these instruments really form an important part of the work of the establishment? If they do, it will be well to reflect that the great ocean liners, obliged to make their time in all states of the weather, must be navigated as carefully as a ship of war, and that it costs their owners nothing to inspect and issue the necessary instruments. Every captain is assumed to be competent for this duty, and we can find no record of a case in which the loss of a ship was traced to the imperfection of a sextant, spy-glass or chronometer.

What was the Observatory built for? What do the scientific men of the country and of the world think of its work? What credit does it do the officers of the navy concerned in its management? What relation has its work to the wants of the naval or any other branch of the public service? What measures are taken by the Navy Department to insure its scientific output being of real value? We are unable to find an answer to these questions in any official publication.

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## *CLIMATOLOGY AS DISTINGUISHED FROM METEOROLOGY.*

THE term Climatology is very frequently treated as synonymous with Meteorology. There is an important distinction, however. which should be generally recognized. Climatology is a distinct branch of meteorology, an application which should not be confounded with the broader subject.

Meteorology includes, in the broadest sense, the various atmospheric phenomena. The subject may be conveniently divided into two parts: The study of the laws and principles involved in the movements of the wind; the formation of clouds; the formation and precipitation of rain, snow and hail; the absorption and radiation of heat and the like. The second part consists of

the statistical records of the extent and frequency of the changes of the various atmospheric phenomena.

Climatology is a function of these phenomena and should be expressed in terms of the development of organic life. Climatic changes produce, in many ways, more apparent changes in plants than in animals, and they should be taken as the standard in the interpretation of our meteorological data. Many plants are far more sensitive in recording climatic changes than our meteorological instruments. There are localities where the character of the leaf or the peculiar excellence of the fruit produced show peculiarities in the climate which the instruments fail altogether to record, or rather which we have never yet been able to deduce from the ordinary meteorological records. The development of plant life should, therefore, be taken as the standard with which our instruments should be compared and our methods adjusted in order that the elements of climatology may be worked out from our meteorological records.

Climatology is not a simple summation, but a complicated expression involving the general relation of certain functions of meteorological elements, the values of which we do not as yet understand. The principal elements influencing the economy of plant life are temperature, humidity, wind velocity, water supply and sunshine. Within certain limits the activities of the plant are dependent upon the relation between these elements. Thus temperature causes evaporation, the relative humidity and the velocity of the wind control evaporation, while the moisture supply in the soil provides the plant with water to replace that lost by evaporation. The influence of all depends upon the total intensity of the sunshine.

The rainfall, although a very important meteorological element and of great economic and commercial importance, is not considered a factor in climatology, as it is not the immediate source of the water supply of plants. The soil is the receptacle of the rainfall and, through the resistance it offers to the descent of water and through capillary action, maintains the water at the disposal of plants. Hence the moisture content of a soil is an essential factor in climatology. Furthermore, as the soils in the same field may differ greatly in their power to retain water, we may have very different climates over very small areas. With forty inches of annual rainfall the soil may be so open and porous and retain so little moisture that the conditions may be truly arid. We have small areas of truly desert lands in our Eastern States. On the other hand, with only eight or nine inches of annual rainfall there are some soils so retentive of moisture that they will produce good crops with careful and thorough cultivation.

The general relation of these elements may be expressed in very general terms in the following equation :

$$\text{Sunshine}\left(\frac{\text{Temp.} \times \text{wind veloc.}}{\text{Humid.} \times \text{soil moist.}}\right) = \begin{matrix}\text{Const. condition}\\ \text{of plant growth.}\end{matrix}$$

This is but an expression of facts perfectly well known to greenhouse men. It will be seen from this that to maintain constant conditions of growth any marked change in one of the elements must be followed by a change in one or the other of the remaining elements. Thus, if the temperature rises, the wind must fall or the humidity or soil moisture increase. If the humidity increases, the temperature or wind velocity should increase or the soil moisture should decrease. The sunshine should be recorded by the total intensity rather than by the duration. If the intensity should decrease, the other elements should all be lowered and *vice versa*. If the above equation holds, it appears that the change in either the humidity or soil moisture or both must be

relatively greater than the change in temperature. We have here, then, the principle upon which climatology should be worked out. Given a plant whose pedigree and habits of growth are well known, and a daily range in temperature from 65 to 70 degrees, what range of moisture in the soil can the plant stand? what relative humidity? wind velocity? and what intensity of sunshine? With a certain amount of sunshine, what temperature, humidity, moisture and wind velocity are necessary to maintain the favorable conditions of growth? This is climatology, and there is no reason why the approximate relation of these elements should not be worked out for different classes of plants and for different periods of their growth. The florist knows how to control these conditions to produce the development he desires or to mature the plant at any time. He does this by watching the plant itself, using the thermometer merely as an indicator of the changes he makes in the temperature. It is intuition on his part which he can not explain. It is a matter of experience and observation which he can not impart to others. If the meteorologist should observe and record these changes by his instrument as the florist is observing and controling the development of his plants it should be possible to express the relation of the climate in language which could be imparted to others. This applies also to field culture.

One encouraging thing in this conception of climate is the fact that through cultivation we may very materially control the water supply of the soil. As this is an essential element of climate, we have then the power of modifying the climate of any locality to a considerable extent.

As the relation shown in the above equation is between certain functions rather than between the values as expressed in our ordinary meteorological tables, the equation should be written in still more general terms. Furthermore, the conditions favorable for one class of plants are not favorable for others, and the conditions favorable for the growing period of many of our crops are not favorable for the ripening period. The general equation should then be written as follows, the Greek letters standing for certain functions of the elements of which we do not as yet know the values:

$$\psi(s)\left(\frac{\phi(t)\quad\theta(v)}{\Gamma(h)\;\Delta(w)}\right)=k \tag{1}$$

$$\psi'(s)\left(\frac{\phi'(t)\quad\theta'(v)}{\Gamma'(h)\;\Delta'(w)}\right)=k' \tag{2}$$

where $s=$ intensity of sunshine; $t=$ temperature; $v=$ velocity of the wind; $h=$ relative humidity; $w=$ soil moisture; and $k=$ the constant conditions favorable for plant growth. Equation (1) may represent the conditions favorable for the vegetative or growing period and equation (2) the conditions favorable for the ripening or fruiting period. The values for some of the elements may be the same in both equations or they may all be different.

Climatology is thus shown to be the relation between the meteorological elements as measured by the development of the plant.

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## *THE AGE OF THE ARTIFACT-BEARING SAND AT TRENTON.*

ON three different occasions during the past summer I examined the deposits on the Lalor farm at Trenton, in which numerous artifacts have been found. So far as my observation goes, nothing was seen to prove that they were not *in situ*. In all cases noted they were found with longer diameters horizontal, *i. e.*, in the position they would naturally occur if their age is the same as that of the sand in which they are found. No positive evidence was noted that the sand had been so disturbed that they might have been intruded from above.